A Gravitational Wave Detector Based on an Atom Interferometer

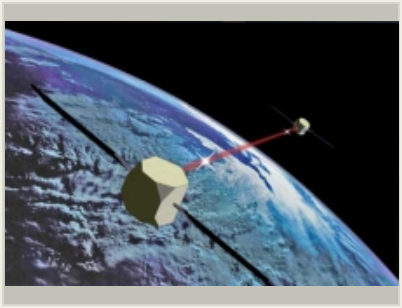
Completed Technology Project (2013 - 2015)

Project Introduction

Gravitational waves are tiny perturbations in the curvature of space-time that arise from accelerating masses – according to Einstein's general theory of relativity. The first hint that these waves existed was spotted in 1974 as a gradual decrease in orbital period of pulsars. However, no one has directly detected a gravitational wave, not even the operational ground-based Advanced LIGO antennas. Our space-based gravity wave detector, equipped with Atom Interferometers (AI), has the potential to enable exciting science spanning the gamut from investigations of white dwarf binaries to spiralling black holes, and cosmologically significant phenomena like inflation. This new measurement approach, capable of higher, scientifically more interesting frequencies of operation, interferometer architecture, and mission concept would open a whole new window on the origin of our universe, heralding a deeper understanding of the fundamental laws of physics. Unlike light, Gravitational Waves (GW) permit observations beyond the so-called surface of last scattering; that is, before the white hot fog of hydrogen plasma cooled to give way to the formation of atoms. Goddard has teamed with Stanford to explore this innovative detector concept. We are proposing to analyze and better understand the realm of applicability of this new, "disruptive" technology of atomic interferometry for exploring GW physics. Cold atom-based inertial sensors have recently made it out of the laboratory and are in the process of being engineered and ruggedized for a variety of real-world applications in the fields of navigation and remote sensing, including some very demanding mission applications. Gravitational wave detection is arguably the most compelling scientific application for atomic quantum sensors of this sort in space.

Anticipated Benefits

Our space-based gravity wave detector, equipped with Atom Interferometers (AI), has the potential to enable exciting science spanning the gamut from investigations of white dwarf binaries to inspiralling black holes, and cosmologically significant phenomena like inflation. This new measurement approach, capable of higher, scientifically more interesting frequencies of operation, interferometer architecture, and mission concept would open a whole new window on the origin of our universe, heralding a deeper understanding of the fundamental laws of physics.



Project Image A Gravitational Wave Detector Based on an Atom Interferometer

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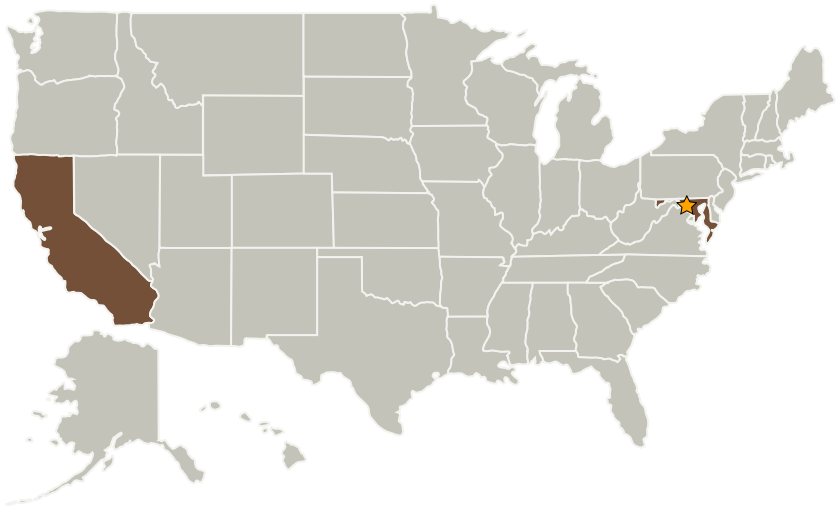
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland
Stanford University(Stanford)	Supporting Organization	Academia	Stanford, California

Primary U.S. Work Locations	
California	Maryland

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

Eric A Eberly

Principal Investigator:

Babak N Saif

Co-Investigator:

Mark A Kasevich

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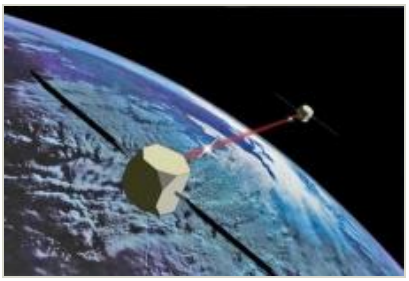
Images



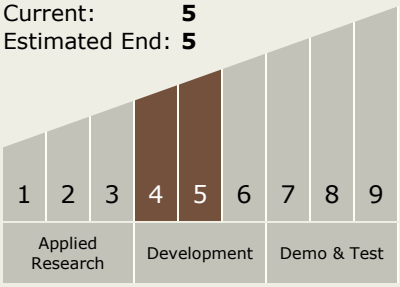
13750-1390590962902.jpg
Project Image A Gravitational Wave Detector Based on an Atom Interferometer
(https://techport.nasa.gov/image/102321)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Technology Maturity (TRL)

Start: **4**
Current: **5**
Estimated End: **5**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.2 Structures
    - TX12.2.2 Design and Certification Methods

Target Destinations

Foundational Knowledge, Earth